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## MASTER CYLINDER, ESPECIALLY FOR A CONTROLLED BRAKE SYSTEM

BACKGROUND OF THE INVENTION

The invention relates to a master cylinder, especially for a controlled brake system, comprising at least one piston displaceable in a housing, which is sealed in relation to a pressure chamber by means of a sealing element arranged in an annular groove of the housing, said pressure chamber being connectable to an unpressurized supply chamber by means of transverse bores provided in the piston.

A master cylinder of this type is e.g. disclosed in DE 101 20 913 A1, and the transverse bores therein have a small cross-section in order to keep the lost travel of the master cylinder as short as possible. When used in a controlled brake system such as a brake system with traction slip control (TSC) or an Electronic Stability Program (ESP), a pump will replenish pressure fluid from a pressure fluid tank through the master cylinder in the case of control intervention. It is disadvantageous in the arrangement that the small cross-section of the transverse bores produces an excessive throttling resistance and the required pressure fluid of the pump cannot be provided at a sufficiently quick rate.

EP 0 807 042 A1 discloses designing the transverse bores as slots which extend in a circumferential direction of the piston. As an outside surface of the piston (peripheral surface) is used to guide the piston, it is necessary to debur the slots on the outside surface of the piston. To this end, suggestions have been made to arrange the slots in the bottom of a circumferential outside groove, necessitating also the circumferential outside

groove to be machined in order to prevent sharp edges and damage to the sealing element. It is also disadvantageous that an inside sealing lip of the sealing element, when overriding the circumferential outside groove, is urged by a preload into the outside groove, which can also cause damage or torsion of the inside sealing lip.

In view of the above, an object of the invention is to provide a master cylinder, which is improved in this respect.

#### SUMMARY OF THE INVENTION

According to the invention, this object is achieved in that recesses are arranged on an inside surface of the piston into which the transverse bores open. This obviates the need for a sophisticated machining of the outside surface of the piston, on the one hand, while, on the other hand, the length of the transverse bores, i.e. the axial extension of the transverse bores, is reduced, whereby reduction of the throttling resistance is achieved. In addition, the lost travel of the master cylinder can be maintained small.

To simplify the producibility of the piston, the piston has on one side a substantially bowl-shaped wall with a first inside diameter and a second inside diameter, with the second inside diameter being larger than the first inside diameter, and with the transverse bores being arranged in a zone between the first and second inside diameters.

In a favorable improvement of the invention, the recesses are configured as a circumferential radial inside groove which can be produced with little effort. Finishing the inside groove is

unnecessary. In addition, the piston can accommodate axial forces, which act on the piston when the piston strikes against the housing or the second piston, without any deformation because the wall thickness of the piston is not weakened.

Another favorable embodiment of the invention is achieved in that the recesses are configured as tooth interspaces of a toothed profile on the inside surface of the piston, with the recesses favorably extending in an axial direction until the end of the piston. It is thus possible to manufacture the piston with the recesses in a deep-drawing process, without needing any additional machining effort for making the recesses. In addition, the wall thickness of the piston is reduced only partly, with the result that the piston can accommodate the axial forces that develop without being deformed.

To ensure an especially simple manufacture of the transverse bores, opposite transverse bores have parallel boundary surfaces. This fact allows fabricating opposite transverse bores practically at the same time.

Preferably, the transverse bores have the shape of an oblong hole, whereby the throttling resistance can be reduced even further.

In a favorable embodiment of the invention, the transverse bores can be manufactured by shaping, e.g. by punching, or by displacing a drill in a radial direction relative to a longitudinal axis of the piston.

Tests have proven that a ratio of the value of roughly 1 is a favorable ratio of the length of bore relative to the diameter of

bore or the length of bore relative to the width of the transverse bores, respectively.

The invention is explained in the following by way of the drawing showing embodiments.

#### BRIEF DESCRIPTION OF THE DRAWINGS

In a greatly schematic view:

Figure 1 is a longitudinal cross-sectional view of a first embodiment of a master cylinder of the invention;

Figure 2 is a longitudinal cross-sectional view of a first piston of the first embodiment of a master cylinder of the invention;

Figure 3 is a partial view of the piston of Figure 2 in a cross-section taken along the line B-B in Figure 2;

Figure 4 is a partial view of a first piston of a second embodiment in a longitudinal cross-section;

Figure 5 is a partial view of the piston of Figure 4 in a cross-section taken along the line C-C in Figure 4;

Figure 6 is a partial perspective view of the piston of Figure 4;

Figure 7 is a longitudinal cross-sectional view of a third embodiment of a master cylinder of the invention;

Figure 8 is a partial view of a first piston of the third embodiment of a master cylinder of the invention, and;

Figure 9 is a partial view of the piston of Figure 8 in a cross-section in the zone of the transverse bores.

#### DETAILED DESCRIPTION OF THE DRAWINGS

Figure 1 shows a longitudinal cross-sectional view of a first embodiment of a master cylinder 1 which is e.g. used in a controlled brake system with traction slip control (TCS) and/or Electronic Stability Program (ESP) and is designed in a plunger and tandem construction. The mode of function of a master cylinder 1 of this type is principally known so that only the features, which are essential to the invention, are mainly described.

The master cylinder 1 comprises a first and a second piston 3, 4 being displaceable in a housing 2, and an annular groove 23, 24 of the housing 2 accommodates a circular sealing element 5, 6 with a dynamically applied inside sealing lip 26, 27 and a statically applied outside sealing lip 28, 29. The dynamically applied inside sealing lip 26, 27 bears with a first sealing surface against the piston 3, 4, while the statically applied outside sealing lip 28, 29 bears with a second sealing surface against a bottom of the annular groove 23, 24. An outside surface 30, 31 of the pistons 3, 4 serves as a guiding surface.

In an inactive state of the master cylinder 1 as shown in Figure 1, a first and a second pressure chamber 7, 8 connect to an unpressurized pressure fluid tank (not shown) by way of a pressure fluid channel 32, 33 and a supply chamber 11, 12 in the

housing 2 as well as by way of transverse bores 9, 10 in a bowl-shaped wall 21, 22, which is provided at a side 36, 37 of the first and the second piston 3, 4. Depending on the type of design of the master cylinder 1, a number of four to twenty-four transverse bores 9, 10 are arranged in an evenly distributed way at the periphery of the piston 3. Pistons 3, 4 are preloaded by means of compression springs 34, 35.

The compression spring 34, 35 is arranged, at least in part, inside the bowl-shaped wall 21, 22. A centric pin 38, 39, which ends before its axial exit from wall 21, 22 penetrates wall 21, 22 centrally. End 40, 41 includes a stop 42, 43 for a sleeve 44, 45 cooperating with a collar 46, 47 in such a fashion that sleeve 44, 45 is adapted to be telescoped within limits in relation to the pin 38, 39. More specifically, sleeve 44, 45 with the compression spring 34, 35 is urged into the interior of the piston during actuation. As can be seen, stop 42, 43 preferably is an annular disc, which is riveted, especially wobble-riveted, to pin 38, 39. The other end of the sleeve 44, 45 comprises the plate-like collar 48, 49 for abutment of the compression spring 34, 35.

The first piston 3 displaces in the actuating direction A for actuating the master cylinder 1. As this occurs, the movement of the first piston 3 is transmitted onto the second piston 4 by way of the compression spring 34. As soon as the transverse bores 9, 10 are in the zone of the sealing elements 5, 6, the so-called lost travel of the master cylinder 1 is covered because pressure fluid can no longer propagate from the supply chambers 11, 12 through the transverse bores 9, 10 into the pressure chambers 7, 8. The connection between the pressure chambers 7, 8 and the

pressure fluid tank is interrupted, and pressure develops in the pressure chambers 7, 8.

The two serially arranged pistons 3, 4 of the master cylinder 1 are almost identical in their design and their mode of function so that only the first piston 3 will be described further.

It can be necessary in a TCS or ESP intervention, when the piston 3 is in the non-active or active state, to aspirate pressure fluid from the pressure fluid tank through the pressure chamber 7 in the direction of the wheel brakes, what is preferably executed by means of a pump, the inlet of which can be connected optionally to the pressure chambers 7, 8 of the master cylinder 1 or to the wheel brakes in order to deliver fluid in the direction of the wheel brakes or in the direction of the master cylinder 1 (return principle). In the event of TCS intervention, in the inactive state of the master cylinder 1, pressure fluid is aspirated from the pressure fluid tank through the pressure fluid channel 32, the supply chamber 11, the transverse bores 9, and the pressure chamber 7. In the event of ESP intervention in the active state of the master cylinder 1, replenishment takes place additionally by fluid flowing over the outside sealing lip 28 of the sealing element 5, as the lip tilts over in the direction of the inside sealing lip 26 due to the suction pressure and, as a result, the sealing surface of the outside sealing lip 28 no longer bears against the bottom of the annular groove 23. In order to provide the pump quickly with sufficient pressure fluid in the event of a TCS or ESP intervention, in particular in the inactive position of the master cylinder 1, it is necessary to keep the throttling resistance of the transverse bores 9 as low as possible. However, also the lost travel of the master cylinder 1 shall be minimized to the greatest extent possible.



Figure 2 shows the first piston 3 of the first embodiment in a longitudinal cross-section, and Figure 3 shows a partial view of the piston 3 in a cross-section taken along line B-B in Figure 2.

As can be seen in Figure 2, the piston 3 has a substantially bowl-shaped design at side 36 and a first inside diameter D1 and a second inside diameter D2, with the second inside diameter D2 being larger than the first inside diameter D1, whereby manufacture of piston 3 is simplified. The transverse bores 9 are evenly distributed at the periphery of piston 3 in a zone between the two inside diameters D1, D2 and open into recesses 15 which are provided on an inside surface 13 of piston 3. As can be seen in Figure 2 in particular, the recesses 15 are designed as a circumferential radial inside groove.

As the wall thickness of the bowl-shaped wall 21 is not weakened at end 19, the piston 3 can accommodate axial forces without deformation, the forces acting on it when the piston 3 strikes against the second piston 4. Abutment of the piston 3 will occur, for example, in a case of circuit failure.

As can be taken from Figure 3, the transverse bores 9 have a diameter of bore D and a length of bore L, and the ratio of length of bore L and diameter of bore D has a value of roughly 1, which has proven to be especially favorable. The inside groove 15 thus reduces the length of bore L and, hence, the throttling resistance of the transverse bores 9.

Figures 4 to 6 show in partial views and cross-sections a first piston 3 of a second embodiment of a master cylinder 1, which largely corresponds to the embodiment of Figures 1 to 3, so that

features that correspond to each other have been assigned like reference numerals and there will be no repetition of related parts of description. Therefore, reference is made exclusively to the basic differences in the following.

It becomes apparent especially from Figure 5, which shows a cross-section along the line C-C in Figure 4, and from Figure 6 that the transverse bores 9 open into recesses 17 which are configured as tooth interspaces of a toothed profile on the inside surface 13 of the piston 3. The recesses 17 extend in an axial direction until the end 19 of the piston 3, whereby manufacture by means of deepdrawing the piston 3 is permitted, and the recesses 17 can be manufactured without additional machining step.

In this embodiment, the wall thickness of the bowl-shaped wall 21 at the end 19 is weakened only in part, with the result that the piston 3 can accommodate axial forces without deformation also in this case.

Figures 7 to 9 show partial cross-sectional views of a third embodiment of a master cylinder 1, which largely corresponds to the two above-described embodiments according to Figures 1 to 6, so that features that correspond to each other have been assigned like reference numerals and there will be no repetition of related parts of description. Therefore, reference is made exclusively to the basic differences in the following.

The master cylinder 1 of the third embodiment comprises a first and a second piston 53, 54 displaceable in the housing 2 and

having a substantially bowl-shaped wall 57, 58 on one side 55, 56.

Compared to the first two embodiments, the master cylinder 1 of the third embodiment includes spring assemblies 61, 62 used to preload the pistons 53, 54. The spring assemblies 61, 62 respectively comprise the compression spring 34, 35, a dowel pin 63, 64, as well as two tensioning sleeves 65, 66, 67, 68 in each case, with the result that a centrically arranged pin that is illustrated in Figure 1 becomes unnecessary. It is thereby possible to manufacture the pistons 53, 54 in a relatively simple fashion as plastic parts or as metallic turned parts.

In the bowl-shaped wall 57, 58, the pistons 53, 54 include transverse bores 50, 51 which are arranged at the periphery of the pistons 53, 54 evenly distributed in a zone between the two inside diameters  $D_1$ ,  $D_2$ , and which open into recesses 15, 16 provided on an inside surface 59, 60 of the pistons 53, 54. The recesses 15, 16 are configured as a circumferential radial inside groove like according to the embodiment of Figure 2.

The two serially arranged pistons 53, 54 of the master cylinder 1 are almost identical in their design and mode of function so that only the first piston 53 will be described in detail.

As can be seen in Figure 8, which is a partial view of the first piston 53, the transverse bores 50 have the shape of an oblong hole with a length  $L_1$  and a width  $B$ . Designing the transverse bores 50 as oblong holes is advantageous because the throttling resistance can thus be further reduced.

In particular Figure 9, which is a partial cross-sectional view of the second piston 53 in the zone of the transverse bores, makes it clear that the transverse bores 50 have a length of bore L. The ratio of length of bore L to width B has a value of roughly 1, which has proven to be especially favorable. The inside groove 15 hence reduces the length of bore L and, thus, the throttling resistance of the transverse bores 50.

It can further be seen that opposite transverse bores 50 have parallel boundaries 52, and the transverse bores 50 can be manufactured e.g. by shaping, e.g. by punching, or by displacing a drill in a radial direction relative to the longitudinal axis M of the piston 53.

List of Reference Numerals:

- 1 master cylinder
- 2 housing
- 3 piston
- 4 piston
- 5 sealing element
- 6 sealing element
- 7 pressure chamber
- 8 pressure chamber
- 9 transverse bore
- 10 transverse bore
- 11 supply chamber
- 12 supply chamber
- 13 inside surface
- 14 inside surface
- 15 recess
- 16 recess
- 17 recess

19 end

20 end

21 wall

22 wall

23 annular groove

24 annular groove

26 inside sealing lip

27 inside sealing lip

28 outside sealing lip

29 outside sealing lip

30 outside surface

31 outside surface  
32 pressure fluid channel  
33 pressure fluid channel  
34 compression spring  
35 compression spring  
36 side  
37 side  
38 pin  
39 pin  
40 end  
41 end  
42 stop  
43 stop  
44 sleeve  
45 sleeve  
46 collar  
47 collar  
48 collar  
49 collar  
50 transverse bore  
51 transverse bore  
52 reference surface  
53 piston  
54 piston  
55 side  
56 side  
57 wall  
58 wall  
59 inside surface  
60 inside surface  
61 spring assembly  
62 spring assembly

63 dowel pin  
64 dowel pin  
65 tensioning sleeve  
66 tensioning sleeve  
67 tensioning sleeve  
68 tensioning sleeve

A     actuating direction  
D     diameter of bore  
D1    diameter  
D2    diameter  
B     width  
L     length of bore  
L1    length  
M     longitudinal axis